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THE WEAPON SYSTEM ACQUISITION PROCESS: CONTROLLING COSTS THROUGH TECHNOLOGY MANAGEMENT

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A Monograph

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ABSTRACT

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The major thesis of this paper is that through the management of technologies, better cost controls can be established for the acquisition process. The paper addresses only the conception and development phases of the acquisition process. This deliberate restriction is made because advanced technology--the practical application of research findings--is often blamed as a major reason for cost overruns experienced in the development of a weapon system. The paper examines factors contributing to R&D costs, illustrates that technical difficulties lie at the root of many costs overruns, establishes a relationship between technology and cost estimates, discusses approaches to treating technology in cost estimates, and suggests some methods for controlling costs in the acquisition process. These suggestions are: Design with attainable goals; use available technologies; and encourage private investment in R&D. The paper emphasizes that management must develop an understanding of the magnitude of the technology required to achieve a desired level of sophistication in a weapon system and must be willing to trade-off performance and time requirements to stay within the cost constraints.

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INTRODUCTION

"Arms cost overrun up $1 billion in a 3 month period" charged Rep. Les Aspin (D-Wis) quoting from a General Accounting Office (GAO) report. The report also showed that 47 major weapons systems are estimated to cost $29.4 billion more than originally planned. "Despite many years of well-publicized criticism, apparently the Pentagon is continuing its wasteful ways."[1]

Such charges have long been leveled at Department of Defense (DOD) for its handling of the weapon systems acquisition process. In turn, DOD has recognized the need for improving the acquisition process. Former Defense Secretary Robert McNamara used systems analysts and "total package buys" in an attempt to control costs. Secretary of Defense Melvin Laird upon assuming office in 1969 said:

> we had to face up to a number of problems and breakdowns in the weapons acquisition process that had developed over the years. Nearly every new weapons system was turning out to be substantially more costly than estimated when the system was first authorized.[2]

In critiquing the acquisition process, Secretary Laird indicated that many weapon system programs had problems because they were "poorly defined from the beginning" and "more performance was requested than was really needed" in the weapon system. He continued, "this tendency too often was encouraged by over-optimism in the evaluation of the technical difficulties involved

in achieving desired performance," and this tendency also encouraged underestimates of the "time and cost that would be required for development."[3] Secretary Laird concluded that inadequate allowances had been made for "trading off some system capabilities or characteristics in order to meet cost targets." Additionally, he pointed out that many of the target dates for a weapon system to ènter the inventory were "earlier than was really necessary." This caused unnecessary concurrence between the development and production phases and often resulted in forcing a system into production before the development was finished. Secretary Laird's approach to solving these problems was to encourage "less structured approaches" to the entire process, to establish milestones at which point the system was examined for "completeness" before proceeding to the next step, to provide for "trade-offs" between performance, time schedule and cost, and to "fly-before-you-buy."[4]

Secretary Laird amplified his position on the acquisition process in Department of Defense Directive 5000.1. This directive recognizes the need for "a strong and usable technology base" for use in weapon systems acquisition. This base will be maintained by "conducting research and advanced technology effort independent of specific defense systems development." Significant advances in technology at minimum cost is the stated objective of this effort.[5]

The foregoing can be summed up to say that DOD recognizes the need for technology--the practical application of research findings--in overcoming some of the technical difficulties experienced in the weapon system acquisition process. While it is recognized that this process covers "the conception, development, and production of technically advanced weapons for ultimate use by the armed forces,"[6] this paper will address only the conception and development portions of the process in order that their relationship to technology can be highlighted. This deliberate restriction is made because advanced technology is often blamed as a major reason for the cost overruns experienced in the development of a weapon system.[7] The paper will examine the relationship between technology and research and development (R&D) cost estimates and suggest that through the management of technologies, better cost controls can be established for the R&D portion of acquisition process.

The approach used in the examination is to first look at some factors contributing to R&D costs and then to illustrate, through several cited works, that technical difficulties lie at the root of many cost overruns. This is followed by the development of the relationship between technology and cost estimates. A discussion of some approaches to cost estimating, and how these estimates treat technology, is followed by some suggested methods for controlling costs. A summary concludes the paper.

FACTORS CONTRIBUTING TO R&D COSTS

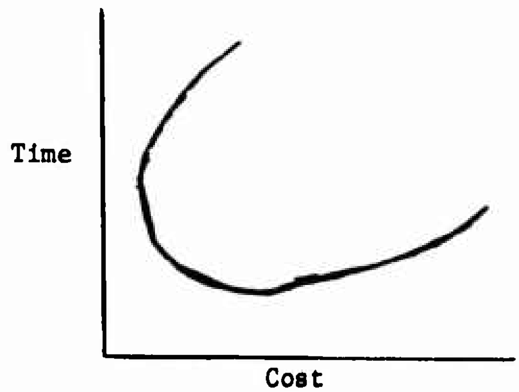
"The financial ramifications of R&D are so vast as to be worthy of an entire book, and a number have been written."[8] Estimates of the costs of a given project or program can be widely disparate owing to individual or organizational variations in methodology and interpretation. Individual, or organizational, assessments of the uncertainties to be encountered in a particular developmental program are based on the experience and methodologies used by the estimator. It is possible, therefore, to over, or under, estimate the costs associated with these uncertainties. These estimates in turn affect the cost of the program. In a large R&D organization it is possible to shift these overruns, or underruns, to other projects or overhead. This is done to make this particular program appear "financially sound." These manipulations, however, must be done at the expense of other projects or company monies. Each project incurs certain development costs relevant to its size, complexity, advancement of the state-of-the-art, development time, etc, which should be charged to the project.

Edwin Mansfield, noted economics consultant and Professor of Economics at the Wharton School, University of Pennsylvania, mentions five major determinants of development cost.[9] First, the dominant factor in cost is the product or development program size and complexity. The larger the size and the more

complex a product is, the larger the number of components, materials, and R&D resources that will be required during its development. The interdependency between components requires that changes in one may result in changes in others. This is more apt to be the case as interdependency increases.

Second, the magnitude of the advancement of the state-of-the-art being attempted affects costs. Large advances normally require more components to be used and more tasks be performed. These added functions increase the probability of mistakes, ergo, costs rise. The uncertainty, which is more prevalent in such programs, can be reduced by additional testing and research which also adds to the development cost.

Third, many scholars of R&D believe that the relationship between development time and development cost is similar to that shown below:



As development time is shortened, development cost may decrease to a point but then begins to increase because more tasks must be carried out concurrently rather than sequentially. This requires that more personnel resources be allocated at the same time which in turn may degrade the overall efficiency. Each task generates inputs and experience which can be useful to other related tasks and activities. As more tasks are performed concurrently, the opportunity of applying the gained knowledge to other tasks is lessened. This can foster false starts and cause redesign which add to the development cost.

Fourth, advances in basic knowledge and test procedures which improve the prediction of relevant phenomena can effect a reduction in development costs. A cost reduction may also be realized when improvements in components and materials reduce the quantity needed.

Fifth, the implementation of a sound development strategy for the coordination of research projects, the allocation of resources, product marketing, etc., enables a manufacturer to plan R&D more effectively. This may reduce costs through improvement in the firm's administration of their R&D programs.

Of the five factors espoused by Mansfield, only the second, the magnitude of the advance being attempted, or the challenge to the state-of-the-art, presents a real challenge to the cost estimator. Certainly, the larger the project, the more one could

expect it to cost. The more people employed at a given time, and the independence of the tasks performed one to another, the more the cost. One can also predict, with some degree of accuracy, that the application of advances in knowledge, test procedures, materials and the development of a well coordinated approach to a problem, will result in R&D cost reductions. However, the uncertainties, or technical difficulties as they are more commonly referred to, encountered in a given project cannot be accurately forecasted. One can only make provisions for such "uncertainties" or "technical difficulties."

TECHNICAL DIFFICULTIES

In their book, The Weapons Acquisition Process, an Economic Analysis, Peck & Scherer put forth their thesis that "the weapons acquisition process is characterized by a unique set of uncertainties which differentiates it from other economic activity."[10] They advanced the theory that much of the uncertainties associated with the acquisition process are brought about by the rapidly changing technologies. As these changes occur, or new technology developed, their applications to, or impact upon, society are not fully understood and doubts are created. The authors concluded their work by inferring that the government placed too much emphasis on time and quality considerations rather than cost

reductions and trade-offs. Too often the military was rigid in adhering to original requirements when a slight compromise as to requirements or time would have produced an acceptable product with an attendant acceptable cost.

Marshall and Meckling[11] conclude that the main sources of development cost increases in a system were the changes in the initial designs and program plans which were almost invariably brought about by unforeseen technical difficulties. Robert Summers,[12] while he studied only hardware costs, concluded the reason for cost increases was basically the same as Marshall and Meckling's. Hitch and McKean[13] indicate the primary source of cost overrun is the unexpected difficulty caused by technical uncertainty. G. H. Fisher[14] studied the variations in total system cost stemming from changes in the operational concept of system. Fisher concludes that "requirements uncertainty" is the main source of increases in cost estimates. R. D. Carter[15] in his examination of cost estimating techniques concludes, "that variation in cost estimates attributable to cost-estimating uncertainty is small relative to that associated with requirements uncertainty."

TECHNOLOGY AND COST ESTIMATES

The cited examples illustrate that technical difficulties are the main reasons for the increase in the development costs of a system. As a system moves from the conceptual stage to the development stage, it also moves from a paper study to a hardware study. As this transition takes place, the technical difficulties begin. What seemed to be an easily accomplished task on paper is not always so easy to accomplish when working with actual materials. Often research, both basic and applied, must be conducted to acquire the knowledge necessary to solve the problem at hand. Technology, "the state-of-the-art in a socioeconomic environment,"[16] is therefore the systematic utilization of the knowledge acquired through research. It is the application of scientific information. Thus as the technical difficulties are encountered, existing technologies are used in an attempt to solve the problem. Since technology is the product of research, and technological expansion and effectiveness are dependent on R&D,[17] the more R&D that is required, the more the technology will cost.

Decisionmakers dealing with weapons systems must consider the cost of the technologies associated with their systems. This cost should be given visibility at the earliest practical time beginning with cost estimates prepared during the conceptual phase. These estimates should be revised as often as practicable

but as a munimum, they should be revised each time the system moves into a different phase of the acquisition process.

The system cost estimator can make a valuable contribution to the decisionmaker, and to the acquisition process as a whole, if he insures that the cost of the technologies to be used are included in the system's cost estimate prepared for the conceptual and preliminary design deliberations. Unfortunately, this effort is often judged primarily on how well the initial program cost estimate agrees with the final program costs. Because of the numerous program and design changes which take place between the concept design and the production model, initial program cost estimates evaluated in this manner often appear poor, as evidenced by Peck and Scherer.[18] Evaluating the conceptual estimate against the development estimate often makes the conceptual estimate appear to be bad. The $29.4 billion overrun referred to in the introduction was based on a comparison of original to current estimates. Had the comparison been made using the development estimate, the overrun would have been only $13.6 billion.[19] This means the cost estimates of the cited weapon systems increased approximately $16 billion as the systems went from paper studies to hardware studies. However, by any standard, the quality of cost estimates will suffer unless cost estimators are aware of the technical complexity of new systems and the potential of advanced technology to solve pending design and development problems.

APPROACHES TO COST ESTIMATING

These changing technologies can have a significant influence on weapons system's cost. Ideally, the cost estimator should have a good understanding of the cost of the technologies currently available and the technologies yet to be acquired for the system under study. The estimator's problem is further complicated when one considers the technologies applicable to a modern weapons system. New materials, manufacturing methods, electronics, computers, are only a few of the influences on a cost estimate. Comprehension of all the technology brought about by these influences, and the attendant cost, is quite beyond the capabilities of an individual cost estimator. Therefore, the cost estimator must look for ways to simplify the task of considering in his estimates the cost of changing technologies.

There are three general approaches to cost estimation: Analogous system; Industrial Engineering; and Parametric. Each of these approaches is appropriate for use in the preparation of a cost estimate during a particular phase of the acquisition process. The strengths, weaknesses, and appropriateness of each is discussed in the following paragraphs.

The analogous system method is a direct comparison of a new program, or program component, with one, or a few, recent and similar project (s). This method is used to obtain a broad cost

assessment (ball park estimate) of a program. Its advantage is that it can be made quickly without a great deal of in-depth analysis required. It considers technological costs only if the analogous system being used for the comparison accounted for such costs. The disadvantage of this method is its simplicity. The estimate made is based on "guesses" with little factual data to support the costs of those components which differ from the compared system. This approach is not normally used once a system starts into the conceptual phase.

The industrial engineering approach "builds" the cost estimate by adding up the cost of components, e.g. the estimated cost of an individual bolt is multiplied by the number of bolts needed, etc. This approach requires extensive system descriptions and design requirements. Since it uses standards built from time and motion studies, work measurement studies, Gantt Chart analysis, critical-path scheduling, etc., detailed production operations must be known. This estimate works well when the production configuration is known and all problems have been solved. It has definite limitations for use early in the development cycle because of precedural difficulties in handling "unknowns." The industrial engineer approach is the most precise of the three approaches and is usually the basis for production contracts.

The parametic approach produces "an estimate which predicts costs by means of explanatory variables such as performance characteristics, physical characteristics, and characteristics relevant to the developmental process, as derived from experience on logically related systems."[20] The parametric approach looks to the history of similar systems and evaluates the new system in the light of past experiences. This approach includes such intangibles as: schedule slippages due to limitations of funds; technical problems; changes in production rates; contract performance failures; management inefficiencies; labor strikes; and other major factors which may be considered to be "unknowns" in the new system. A major argument against the use of this method is that it tends to produce estimates considerably larger than contractor estimates since it assumes inefficiencies will persist in the new program as they did in previous programs. If management improvements can be clearly identified with their associated costs, the parametric estimate can, and should, be adjusted accordingly.

The parametric estimating approach is required by DOD memorandum to be used in preparing cost estimates presented to the Defense Systems Acquisition Review Council (DSARC).[21] This approach permits a blending of known changes in weapon system management and technology with the uncertainties of weapon system design during the early development phase of the acquisition

process. The parametric estimate, periodically updated by known changes in management, technology, and other data, should then be used as a check on the more definitive engineering cost estimate.

There are also techniques which can be used to assess the validity of the developed cost estimates. While not an estimating approach in the same manner as the three methods previously discussed, STEC PLOT (Study of Trends and Escalation of Costs)[22] is a technique used to apply a "corrective factor" to an estimate. It attempts to determine how funding restrictions, developmental difficulties, estimate errors, and the inability to see into the future increase costs of a system. As such, STEC PLOT makes no attempt to explain the reasons for the general underestimating bias which appears to have occurred in a comparison between past estimates and actual costs. This technique gives probable ranges of costs based on time and funds expended. It is an examination of the perceived progress of the system. STEC PLOT is very useful as a check on a system's cost estimate, expenditures, and progress, but should not be used for developing cost estimates.

All the estimating methods and checks previously described are wholly, or in part, based on Cost Estimating Relationships (CER's). This is a relationship between cost and a system parameter. The development of CER's is based on statistical theory and the statistical processing of historical cost data.

Prediction equations relating costs to system design and program parameters are derived from this process. There are several reasons why a CER approach, which is based on a few program or performance paramters, does not adequately consider either the requisite level of technology or the technological gap between existing and required technology for a specific weapon system's program. Notable among these reasons are: existance of too few estimating relationships; perishability of the historic data base; radical departures from systems found in the data base; and the inability of the relationship to directly relate technology to cost. As a consequence, even the parametric estimate, which is probably the best method for estimating developmental costs, is challenged on its capability to accurately portray costs of certain equipments.

Even though the approaches to cost estimates are technically adequate, the data base used to prepare the estimates often includes data that is faulty, inaccurate, or obsolete. Such faults in the data base will lead to inaccuracies in cost estimates. These inaccuracies can be "purged" from the data base by continuous examination of the base and removing from it detected errors. However, as previously pointed out, R. D. Carter[23] concluded cost-estimating uncertainties were small when compared to the requirements uncertainties.

SUGGESTED IMPROVEMENTS

The essence of this paper thus far has been that technical difficulties, and the attendant advanced technology necessary to overcome these difficulties, has had a significant impact on weapons systems program costs. Program and design changes, often brought about by technical difficulties, have also impacted upon the system's cost. While the cost estimator can make allowances for some of the difficulties that creep into the program, the accuracy of his estimate is dependent upon the number and magnitude of the difficulties. Thus a reduction in the number and magnitude of the difficulties encountered during the acquisition process should reduce the turbulence within the program and as a consequence reduce the cost overruns. To this end, the author would suggest three approaches to controlling cost:

* Design within attainable goals and retain design
* Use available technologies
* Encourage private investment in R&D

As a technique of presentation, the first shall be last and the last shall be first.

ENCOURAGE PRIVATE INVESTMENT IN R&D

The companies engaged in R&D must be willing to invest their monies into researching for better products at lower costs. This would be healthy not only for the federal government but also for the companies involved. The government stands to gain by receiving a better product at a lower cost. Industry would gain because of the competition among the companies involved. The competitor companies would have to research and develop new modern processes, plant designs, and other ways of reducing manufacturing costs. This competition would keep the competitors as viable members of the defense industry since they would be required to marshall their engineering, designing, researching, and innovating skills into an effective force capable of producing more at a lower cost.

Critics of this thesis will immediately say that private industry would not consent to investing their money in such an effort. Yet, there are recent examples of industry investing money in R&D which tends to support this idea. The Industry and Defense Company of the Westinghouse Corporation, when it lost the F-15 radar contract to Hughes Aircraft in 1971, realized that "to survive in the avionics industry, we had to do some soul searching."[24] Instead of waiting for the government to provide development monies, the Industry and Defense Company

invested its own time, talent, and $4 million of private funds into developing an advanced radar system.[25] The advanced technology system developed is basically a modular concept covering the entire spectrum of radars. A family of radars is designed by adding, or subtracting, components from the basic model. The company claims this new radar is "twice as good and costs one-half that of the current F-15 radar."[26] An analysis of what was needed in the Defense market, and a willingness to invest private money in R&D, have given Westinghouse a product which they can offer to the government on a "buy a couple and test them" basis.

In a somewhat different approach to reducing production costs, Thomas V. Jones, president of Northrop Corporation, stated, in testimony before the Senate Armed Services Committee which was seeking ways to reduce the costs in the weapons system acquisition process, that after Northrop had received an order from the Boeing Company to engineer and build the main fuselage for the 747 airliner, "we invested over $60 million . . . in a new plant and equipment. As a result, the total cost of the 200-fuselage order was considerably less than it would have been had we not made that expenditure."[27] Mr. Jones went on to indicate that, if they had not researched methods of reducing the costs but had depended upon existing facilities, the cost of the fuselages would have been considerably higher. "The pressure of commercial

cost competition motivated us to . . . invest substantial amounts of money" into developing advanced manufacturing and materials handling techniques. "We did this because it was sound business for our customer and ourselves."[28]

In the same hearing, Mr. C. L. Johnson, senior vice-president of Lockheed Aircraft Corporation, cited an example of where an investment of $1 million into researching a way to forge rings for the Air Force SR-71 aircraft saved the Air Force $19.25 million in production costs. "That type of technology and that type of application of money can do a great deal."[29]

In the eyes of private industry, "these kinds of investment risks are taken because a profit reward is attractive enough."[30] An examination of the Defense market needs reveals other "attractive" programs that have "potentially large cost and performance savings for the military"[31] if the military encourages private investment in R&D. With military encouragement and private investment, cost savings can be effected in the weapon system acquisition process.

USE AVAILABLE TECHNOLOGIES

An argument could be made as to whether this should be a separate category or included under the subsequent category. The author chose to emphasize this point by making it a separate one. Simply stated, using available technologies means that one

does reinvent the wheel. Many times the technology to solve a particular problem has been available, but those confronted with the problem chose to "rediscover" a solution. Radar was in existence some 20 years before it was "discovered" that reflected radio waves could be used for locating objects. J. C. Maxwell announced his theory of Electromagnetism in the 1860's and H. R. Hertz demonstrated the production and detection of wireless waves in the 1880's, yet, it was 1897 before Marconi began work on the radio.[32]

Mr. C. L. Johnson, in testimony previously referred to,[33] stated that Lockheed could have a lightweight fighter for the Air Force flying in 4 or 5 months after starting the program by using the existing F-15 engine. The Air Force, however, has contracted for a 22-24 month development program for the lightweight fighter. This program calls for the development of a new engine and the 22-24 month schedule is keyed to the availability of the new engine.[34] Mr. Johnson made a similar comment reference the Air Force B-1 program. Lockheed's studies showed, and they proposed, that it was feasible to use engines from the Boeing 747 or the Lockheed C-5A programs for the B-1. However, the Air Force chose to develop a new engine.[35] While there may have extenuating circumstances which dictated the development of a completely new engine, it would appear from feasibility studies that the technology needed was already available.

In answer to Senator Stennis' question, "Do you believe that these high R&D costs are necessary . . .?", Mr. Johnson replied in part,

> I would also recommend a return to our former practice of developing components such as armament or engines which would be available off-the-shelf for different programs. Our recent practice of making new engines, radars, guns, and similar equipment new for every different weapons system leads to extreme costs and lengthy development time.[36]

It is not always possible to use an item directly off-the-shelf as a component in a weapon system. Often it is necessary to research and develop a new item. Yet, there are instances where the available technologies can be used, and the cost of the development program controlled by their use. It is in such instances that the available technologies should be used and no money be spent to reinvent the wheel.

DESIGN WITHIN ATTAINABLE GOALS AND RETAIN DESIGN

The thrust of this suggestion is similar to Mr. Johnson's statement that we don't need new engines, radars, guns, and similar equipment for every system designed. The author contends that a small incremental advance in the technology of one of the components of a system, advances the total system by some measure. It is simply a case of the whole system being made up of the sum of its component parts, or, as defined by Peck and Scherer,

> Weapons System: A composite of equipment, e.g., a manned aircraft, a radar unit, or a satellite with supporting equipment employed as an entity to accomplish a military mission. A weapon system is thus a set of potential military capabilities.[37]

As these capabilities increase, or decrease, the capability of the system as a whole is similarly affected. Since these components interplay one with another, a performance increase in one component will usually result in a "bonus effect" in the performance of the component, or components, with which it interplays. This synergistic action can be put to good use when designing a weapon system. By skillfully selecting and integrating the components of the system, one can produce a total effect greater than the sum of each separate action. Carrying this idea a step further, by making only small, easily attainable advances in the technology of a few of the components in a system, the total effect will be far greater than the sum of the technological advances made. Therefore, by using a proven engine from some other system and innovating in the other componentry, a new light weight aircraft could be developed quicker and at much less expense as alluded to by Mr. Johnson.

Included in this idea is also the reduction of "gold plating" or requiring that the system meet the "desires" of everyone. What should take place in the design of a system is that the prime user and the designer of the system reach an understanding of what the system will look like, what its performance will

be, which components will be improved, and, in general, how this new system will assist the user. Once the system design has been determined, it should not be altered unless it is absolutely necessary because of technical difficulties encountered. If, as explained above, the technological advances to be made are incrementally small and easily attainable, the chances correspondingly will be small that technical difficulties will require system design changes.

The Army's Cheyenne helicopter is an excellent example of "goldplating" or trying to satisfy everyone. It was supposed to escort utility helicopters, destroy tanks, support the soldier on the ground, and many more tasks during all kinds of weather, either day or night.[38] This required large technological advances on many of the system's components. When these advances could not be made within the allotted time, the cost of the aircraft began to soar. Eventually the aircraft became "too expensive" to buy and the system was cancelled. However, had some of the component advances been of a lesser magnitude, an acceptable system might have been in the inventory years ago. As an example, the Cheyenne's speed was to be 210 knots-per-hour (KPH). This would represent a 60-70 KPH increase over the helicopters of the times. After a couple of years of development, a speed of 180 KPH had been achieved; however, to safely reach speeds over 200 KPH required four more years of development and the expenditure

of many more dollars.[40] Had the speed requirement for the Cheyenne been in the neighborhood of 180 KPH, and the other component increases been equally as modest, perhaps the Cheyenne would be in the inventory today. Instead, this system, estimated to have cost the Army appoximately $400 million, has gone down the drain.

An ancillary notion to this major suggestion is the idea of trade-offs. The customer must be willing to trade-off performance for dollars. That is to say that, when the customer and the designer develop the design for the new system, they should determine three levels of performance for each of the major components. These levels-minimum, desired, maximum--would establish the performance envelope for the system. The desired level would be that set of performance characteristics which the customer and the designer desire in the system and feel can be achieved within the time and cost constraints. The minimum level establishes the lowest acceptable performance of the system, while the maximum level establishes the upper bound beyond which it would be impractical to go. This approach allows the developer a degree of flexibility in trying to stay within the intial estimates against which the development program is judged. As the developer reaches the minimum acceptable level in a particular component area, he has the option to continue work toward reaching the desired level, or, he can divert his resources to other areas that may need assistance in reaching the minimum level within the time and cost constraints.

As the minimum conditions are met, and if time and money have not been exhausted, efforts can then be directed toward reaching the desired levels. Thus, the developer has the flexibility to manipulate his resources to produce the best system possible given time, money, and performance constraints.

Critics of this idea will say that the contractor will develop only minimum systems to stay within the system's constraints and reap maximum profits. This may be the philosophy of some of the contractors; however, in the opinion of the author, this is not the approach most contractors would take, particularly in a competitive atmosphere. If it is made known that the production contract will be awarded to that contractor who most nearly meets, or exceeds, the desired level of the system, then barring collusion, the competition among the contractors should bring out the best possible system for the least cost.

Penalizing contractors for failing to meet certain standards is not new. The Army established a penalty clause in the request for its first airplane. The supplier would get the full dollar amount if the airplane went 40 MPH, 90% if it went 39, etc.[41] The current contract for the Army's Utility Tactical Transport Aircraft System (UTTAS) also levies penalties on the contractors if they fail to meet the desired standards.[42] The primary difference between the UTTAS contract and what is proposed in this paper is the flexibility the contractor has in manipulating

his resources to determine which areas will receive priority if the need arises. This proposition also allows the customer to determine which of the developed products most nearly fits his needs and allows him to award production contracts on the basis of the best for the least.

What has been suggested in this section as possible solutions to the reduction of the turbulance within the weapon system acquisition process is simply that good management of the various technologies associated with a system will produce a better product at a lower cost. It is recognized that this has been an aggregated view and that many of the details involved in implementing such ideas have not been discussed. However, it is felt that, if the management philosophies put forth were enthusiastically administered, cost overruns in the weapon system acquisition process could be controlled.

SUMMARY

The potential technologies available for application to development and production of advanced weapon systems are vast and continuing to grow. There are very significant cost implications with respect to new military systems which require successively higher levels of technology. The scope and complexity of modern technology greatly complicate the preparation of advanced system cost estimates. The increasing rate of technological change tends to degrade the relevance of historical data and the validity

of cost estimates based on it. This requires that system cost estimators improve their understanding of the cost implications of new technology and properly reflect these implications in their cost estimates. This will be a difficult and challenging task, requiring significant and continuing cost research efforts.

The role of management in establishing design philosophies, which influence numerous subsequent cost-performance trade-off decisions,has a growing impact on the systems actual cost. Management must develop a clearer understanding of the magnitude of the technology required to achieve the "desired" level of sophistication in a weapon system and must be willing to trade-off performance and time requirements to stay within the cost constraints.

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LTC Inf

FOOTNOTES

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